U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1763

HARVESTING AND HANDLING CITRUS FRUITS IN THE GULF STATES

THE HARVESTING AND HANDLING of citrus fruit has become a highly specialized business, almost apart from the business of production.

From the time the crop is ready to harvest until it reaches the ultimate consumer it is for the most part entrusted to special organizations, many of them cooperatives, which supervise or assume responsibility for the picking, conditioning, packing, shipping, and marketing of the fruit.

This bulletin describes briefly the more important fungus diseases of citrus fruit in the Gulf States, points out other factors that govern its merchantable condition, and shows the relationship between harvesting and handling methods and the maintenance of the fruit in satisfactory condition.

With the growth of the citrus industry many new and improved methods of handling the fruit have been developed. These improved methods of picking, washing, "degreening", polishing, packing, shipping, etc., are described.

This bulletin supersedes Farmers' Bulletin 696, Handling and Shipping Citrus Fruits from the Gulf States.

Washington, D. C. Issued February 1937

HARVESTING AND HANDLING CITRUS FRUITS IN THE GULF STATES

By J. R. WINSTON, *senior horticulturist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry*

CONTENTS

INTRODUCTION

COMMERCIAL FRUIT PRODUCTION cannot be successful unless the crop can be sold at a profit. Citrus fruit, as well as all other perishable produce, must be maintained in a satisfactory merchantable condition. When long-distance shipment to market is necessary, as is the case with most of the citrus fruit grown in the United States, the handling and shipping of the fruit to market becomes a highly specialized business. It is usually conducted by growers' cooperative associations and independent dealers rather than by individual growers. It is the purpose of this bulletin to point out the principal factors governing the merchantable condition of citrus fruit in the Gulf States and the relationship between harvesting and handling methods and the maintenance of the fruit in this condition.

Soundness and good keeping quality are of fundamental importance in the successful marketing of any perishable crop. No system of marketing can procure for the grower the highest price for his product unless it is delivered in sound and attractive condition and remains merchantable for a sufficient time to allow for proper distribution to consumers. If this cannot be done the labor and money invested by the grower in his enterprise are largely wasted.

The preparation of citrus fruit for market involves the use of a number of specialized processes, including washing, polishing, grading, sizing, packing, coloring or "degreening", and refrigeration. General care and attention to details in packing-house operations are required in order to present the consumer with a product that is

uniform in grade, general appearance, size, keeping quality, and edibility. While there remains much room for improvement in methods, it is true that fruit-handling technique has made tremendous advances in the last 20 years, although some of it is the rediscovery of facts recorded by the Chinese centuries ago. In the early days of the Florida citrus industry preparation of the fruit for market was the simplest kind of process, consisting merely of picking the fruit and placing it in any available kind of container and forwarding it by boat to seaboard markets. Later, when railroads were built, small lots went out by local freight. The shipping season was short, uniformity of grade and of pack was unheard of, and a russeted orange was regarded as a variety rather than as a blemished fruit.

Careful handling, in the strict sense now used, has not long been generally regarded as essential to the successful marketing of the crop; now every successful packing-house operator realizes that fruit, even after leaving the tree, is still a living organism, that it respires and therefore is subject to suffocation, and that the normal rate of spoilage may be accelerated by rough and improper handling methods. Spoilage may be reduced by careful handling at all stages of the packing operation, as well as by the timely application of mild antiseptics; it may also be retarded by refrigeration. The general appearance of the fruit and its container on arrival at the market has a great deal to do with the price it will command; therefore the importance of careful grading, packing, and other details is generally appreciated by shippers.

As production increased and competition became keener the primitive methods of handling had to give way to the use of improved machinery and handling practices, although these entail considerable outlay of capital and increase the cost of preparing the fruit for market. The numerous details of this operating procedure require the organization and conduct of a highly specialized service to insure the retention by the fruit going to market of as much of the fresh flavor and appearance as possible.

STANDARDS OF MATURITY

Before the fruit can be shipped to market it must meet the established legal standards of maturity of the State where it is grown and the regulations of the Food and Drug Administration of the United States Department of Agriculture.[1]

The progressive changes in flavor that take place when oranges and grapefruit pass from the stage of immaturity to that of legal maturity cannot be determined by outward appearance. A deliciously flavored fruit may have a green-colored rind, whereas a sour, unripe fruit may have lost all of its green rind color because of varietal characteristics, climatic conditions, or cultural practices. Owing to the long blooming period of citrus fruits, there may be a resulting difference in the age of fruit of similar size, and on account of the conditions outlined even the most conscientious shipper might inadvertently pick some fruits that were not mature unless he was guided

[1] In the enforcement of the Food and Drugs Act, governing interstate shipments, the U. S. Department of Agriculture has adopted the following definition of maturity: For oranges, "the juice of the mature fruit contains not less than eight (8) parts of soluble solids to each part of acid calculated as citric acid without water of crystallization"; for grapefruit, "the juice of the mature fruit contains not less than seven (7) parts of soluble solids to each part of acid calculated as citric acid without water of crystallization." (Food Inspection Decision No. 182.)

by the chemical test. Before the adoption of the above-named standards, therefore, unpalatable fruit was often shipped and sold early in the season. By use of the chemical test, however, the edibility of the fruit can be ascertained, and the demoralizing effect of selling immature fruit can be avoided. With this test as a basis, supplemented in the case of grapefruit with quantitative juice measurements in relation to the size of the fruit, the present legal maturity standards are being enforced by State-employed inspectors. These standards vary somewhat in the different States, but they serve to protect the consumer from being offered immature fruit, and the shipper from the financial losses that occur when unpalatable fruit is sent to market. The green-fruit laws are especially applicable during the early part of the shipping season, when the proportion of legally immature fruit is greatest.

As a precautionary measure, to avoid picking immature fruit, which would be condemned and destroyed, an employee of the packing agency, which is generally responsible for picking the crop, usually makes preliminary tests in the grove ahead of the pickers. Although the State inspectors can make their tests at any time during the handling operation, such tests are usually made when the fruit is ready to be packed.

None of the coloring or degreening treatments applied to citrus fruit ripen or sweeten it in any way, the solids-acids ratio being in no wise affected. If the fruit is not legally mature when harvested it cannot be forced into legal maturity by any known process or treatment.

ORGANIZATION FOR HANDLING THE CROP

In the picking and packing of citrus fruit, as in all other phases of the industry, there is great variation in the magnitude of the operations in different units. The labor and methods involved range from the elaborate organization of personnel in the large packing-house and cooperative association to the small grower and mail-order jobber who does his own picking and personally attends to all the procedures necessary in preparing the fruit for market. The methods employed, however, are fundamentally the same, whether the daily output be 20 cars or 20 boxes. For the purpose of describing these methods, therefore, a résumé of the working procedure of the larger cooperative packing houses will be given.

At the head of the personnel stands the packing-house manager. To him all other employees are responsible, as he in turn is responsible to the growers and others who ship through the organization of which he is in charge. The business details of the packing house are his responsibility, and he must maintain supervision over operating details as well. The manager's chief assistants are the field foreman and the house foreman, each of whom has a number of assistants, depending on the size of the organization.

The field foreman supervises all outside work, including the selection and testing of fruit for maturity and estimating crops, so that at any time during the shipping season he can give the approximate number of boxes remaining on the trees of each grove that supplies fruit to his house. He also must be able to report the average size and quality of the fruit. He oversees the picking crews, assigning them to certain groves and specifying the amount and variety of fruit required for the

day's operations. He is responsible for the proper picking and safe arrival of the fruit at the packing house, where his responsibility ends and the house foreman's begins.

The house foreman has the responsibility of supervising all inside work. If the packing house is small the foreman oversees all of the operations; if it is a large one he has from two to six or more subforemen or supervising clerks, each assigned to some specific phase of the packing operations, such as receiving the fruit, supervising the coloring rooms, grading, packing, loading, etc.

HARVESTING OPERATIONS

PICKING

Aiding the field foreman are the picking captains, each of whom supervises the work of an individual crew of pickers, which consists of 6 to 15 men, usually about 12.

Several score of men may be employed as pickers by one packing house. They are paid on a piece-work basis, which varies according to the fruit picked and the kind of picking desired. During some parts of the season, especially in the earlier part, "spot picking" and picking for size are common practices. This limits the pickers to certain parts of the tree or to particular sizes, and generally under these conditions a higher rate is paid per box. The smaller fruits, too, command a higher rate than the larger. The usual scale for tangerines is about twice that for grapefruit, while oranges are paid for at about two-thirds the tangerine rate. Picking is not an easy job and is sometimes unpleasant. Weather conditions are often severe, and, although the picking is suspended during rainy weather, the men are sometimes caught deep in a grove with no protection from the elements. If the grove is an appreciable distance from the packing house the pickers are transported to and from work on open platform trucks, which also carry the field boxes and ladders.

In picking from trees on which the fruit is beyond the reach of a man on the ground, straight ladders and stepladders are used, the ordinary round-rung straight ladder, ranging in length from 10 to 36 feet, being more commonly used. These are placed against the trees with care to avoid breaking or injuring the branches.

The fruit is removed from the tree by means of clippers made especially for the purpose. Several designs are available (fig. 1).

For the past few years the snub-nosed clipper has been the most widely used. This model helps greatly in eliminating long stems and the danger of "clipper cuts", the common term for the nicking or puncturing of the skin often encountered in fruit clipped with long instruments having shearing edges. However, the older and longer curved scissors model (fig. 2, *B*) facilitates faster picking, since by using it the picker can reach out and pull the fruit toward him, at the same time clipping it from the stem. If the snub-nosed clipper is used, the fruit must be held while being picked. Care is usually taken to clip the fruit close to the "button", leaving no protruding stem to injure other fruit when placed in the field box or while being washed and polished. With careless use of the older type clippers it is not uncommon to find 20 percent of the fruit with clipper cuts or with long stems which easily injure other fruits. Fruit so damaged is likely to decay from blue mold.

"Pulling" of citrus fruit, or picking without the use of clippers, is not commonly practiced with tangerines and oranges, except when the fruits are dead ripe, because of the likelihood of tearing or "plugging" the rind. On the other hand, grapefruit can be pulled during the greater part of the shipping season with but slight likelihood of tearing the rind. With grapefruit there appears to be a distinct advantage in pulling over clipping, for if the "collar" or calyx points are removed from the fruit during the pulling operation the liability to stem-end rot is lessened. If all of the stem button is removed stem-end rot is further reduced. This is the most serious form of

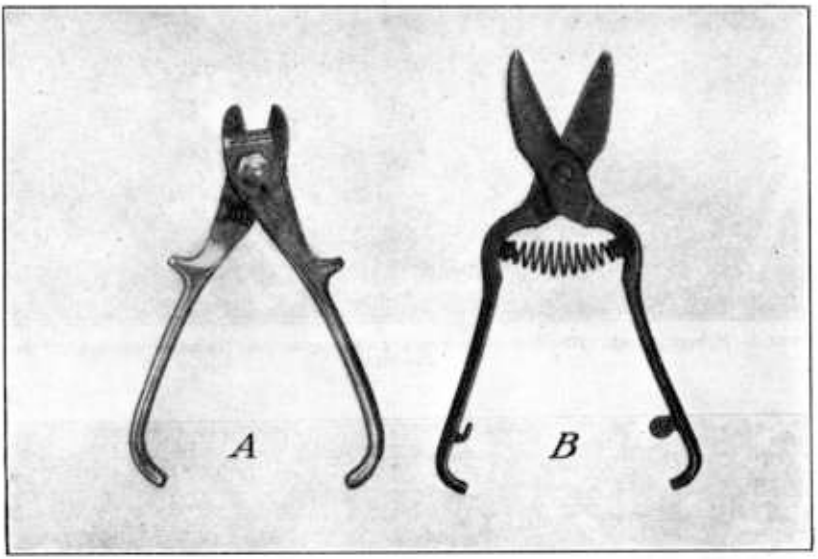

FIGURE 1.—Popular types of orange clippers. Type *A*, having a short shearing edge, is preferred to type *B*, since with it the fruit is less likely to be injured by "clipper cuts."

decay of citrus grown in humid areas. To a large extent, therefore, the responsibility for decay rests with the pickers.

Over his shoulder and hanging at his side, the picker carries a picking sack the capacity of which is about one-half of a field box (fig. 2). While filling the sack, he must be careful not to get it between himself and the ladder, for, as in all stages of handling and preparing the fruit, the danger of bruising must be guarded against. A bruised fruit or one the skin of which is even slightly cut or broken is very susceptible to decay. The sacks are so made that the bottoms, which are open, can be folded up and hooked, in order to keep the fruit from falling out before the picker is ready to descend to the ground and empty it into a field box. To empty the fruit the sack is lowered into the box, the fold is unhooked, and the sack withdrawn, the fruit emptying through the bottom (fig. 2) so that bruising is eliminated. Given "good picking" (fig. 3), that is, trees well loaded with fruit, the ordinary experienced picker can pick, on an average, approximately 80 boxes of oranges or 120 boxes of grapefruit per day. In the more progressive organizations, pickers and all other workers

FIGURE 2.—Pickers at work. Note that the picking bag is kept away from the ladder so as to avoid bruising the fruit.

FIGURE 3.—An "inside" crop of grapefruit, which can be picked fast, but ordinarily does not carry as well as that produced on the outside of the tree.

who handle the fruit are required to wear gloves to keep their fingernails from injuring the tender skin.

FIELD BOXES

The field boxes, in which the fruit remains until ready to go through the packing-house machinery, are usually constructed of cypress, although pine is sometimes used. For durability and lightness cypress is superior, although somewhat more expensive. The size of field boxes is the same for both oranges and grapefruit. The dimensions of the standard Florida box are: Length, 33 inches; width, 12 inches; depth, 13 inches, with a ⅝-inch handle strip nailed across the head. A smaller box, about two-thirds the standard size, is sometimes used, especially for oranges; the jumbo box, which is one-half inch deeper than the standard and has a ⅞-inch handle, is also used. The jumbo is such a large, heavy box that it is not conducive to careful handling, while the smaller box is not generally favored for grapefruit. The average weight of an empty cypress standard field box is about 17 pounds, while a filled box weighs from 100 to 120 pounds, depending on the size and quality of the fruit as well as upon the fullness of the box. There is a space of approximately one-half inch between the boards on the sides and bottom to prevent water and trash (such as leaves and twigs) from accumulating in the boxes and to allow free circulation of air around the fruit. For convenience in handling, the end heads are slotted, and a center partition identical with the heads is used to add strength.

The field box generally used in California is somewhat smaller and lighter in weight than the ⅝-standard Florida box and is without a center partition.

It is generally agreed that the heavy reinforced field box is best adapted to use in Florida, where a large tonnage of grapefruit must be handled, while the lighter, smaller box is better adapted to conditions in California, where the crop consists largely of oranges and lemons.

Unless the crop is of very good quality it is not always possible to secure a packed box from a standard Florida field box of fruit as brought to the packing house unless the field box is overfilled. However, obtaining a packed box from a field box is generally the objective of the grower or owner of the fruit, and particularly of the independent dealer, who often buys fruit by the field box. The desire for a high "pack out", as it is called, frequently results in such undesirable practices as filling the field boxes too full (fig. 4), or piling fruit on top of the boxes after they are loaded on trucks to be taken to the packing house, or in the use of oversize boxes. The boxes are stacked four high on the trucks; if they are filled too full, many fruits are bruised and otherwise injured. Piling fruit on the top boxes causes many to be spilled and dropped in the process of unloading. The desire for a high pack out also commonly results in improper grading. As oversize boxes are too heavy to be handled by one man as carefully as they should be, their use should be discouraged.

HAULING TO THE PACKING HOUSE

In groves where there is insufficient room between the rows of trees for trucks or wagons, the loaded field boxes are usually hauled out on mule-drawn sleds or low-wheeled carts and then transferred to

motortrucks (fig. 5) for hauling to the packing house. Special care is required in the reloading, to prevent bruising or other injury of the fruit.

Only a few years ago practically all of the fruit was hauled from groves to packing houses in wagons having a capacity of about 30

FIGURE 4.—A typical scene where the crop is sold by the box. These boxes are so full that much of the top fruit will be damaged when stacked in loading the truck.

boxes. These have now been supplanted, for even the shortest hauls, by the 1½-ton motortruck hauling from 64 to 80 boxes per load. These trucks carry 100 or more empty boxes back to the groves.

FIGURE 5.—Light motortruck used in hauling fruit from the grove to the packing house. Note that with the hand truck an entire stack of fruit is taken directly from the motortruck to the coloring room.

OPERATION OF THE PACKING HOUSE

Upon the arrival at the packing house the incoming fruit is checked by the receiving clerk. In the large houses he holds a full-time job. He is responsible for the records of receipts and should be able at

any time to tell a grower how many boxes of each variety of fruit have been received from his particular grove. As it is checked, the fruit is removed from the motortrucks onto the receiving platform by means of hand trucks (fig. 7), which carry a full stack (four boxes) at a time. Sometimes the field boxes are transferred by hand from the motortruck, which in this case draws up alongside the receiving platform instead of backing up to it. The boxes are then stacked four or five high and are later moved about by hand trucks. The men who do this work and all shifting of field boxes or packed fruit within the house are called truckers.

Although packing houses differ greatly in size and equipment, the same fundamental theory of arrangement and construction is usually followed to facilitate the "straight line" plan of operation now used so generally in industrial plants. An effort is made to carry the fruit through the various treatments and processes in logical sequence, in order to eliminate extra handling or shifting of the fruit and to save space. The progress of the fruit is usually from the receiving platform on one side of the house to the shipping platform on the other side. In older houses, where additions have been made from time to time, this arrangement is not always possible. A typical floor arrangement is illustrated in figure 6.

In Florida, packing houses are rarely constructed with basements, on account of the higher operating costs. In Texas, basements are more often used, and in California they are in general use, particularly in the nonrefrigerated storage of lemons, advantage being taken of the cool night air, which is generally cooler in that semiarid climate than in the Gulf States.

After having been checked in upon arrival at the packing house, the fruit is in charge of the house foreman, under whose supervision and care it remains until it leaves the house on its way to market. His first duty is to decide what, if any, preliminary treatments are necessary before the fruit is packed.

PRINCIPAL FORMS OF DECAY

SYMPTOMS, CAUSE, AND CONTROL

Citrus fruits are subject to various rots after harvest, depending upon the climatic conditions where the fruit is grown and the handling and storage methods employed. The development of the organisms that cause decay is influenced greatly by the temperature and humidity after harvest as well as by the stage of maturity of the fruit.

PENICILLIUM ROTS

Penicillium rots are the most widespread forms of decay and are variously known as green mold rot, blue mold rot, blister rot, and pinhead rot. They occur for the most part during the cooler months or in fruit that has been held in cool or cold storage for some time. Temperatures between 50° and 70° F. are most favorable for their development. Blue mold rot is caused by *Penicillium italicum* Wehmer, and green mold rot is caused by *P. digitatum* (Fr.) Sacc. The spores are air-borne and are almost omnipresent in all citrus-growing regions, but of course are most abundant where decaying fruit is found.

The early stage of either type of penicillium rot is a small, soft, watery spot sometimes known as pinhead rot. This gradually enlarges and is known as blister rot just before the white fungus growth appears over the central part of the affected area. This growth turns olive green or blue, depending upon which organism causes the rot. Blue mold spores develop inside the fruit as well as on the surface. Green mold spores develop only on the surface. Sometimes both the blue

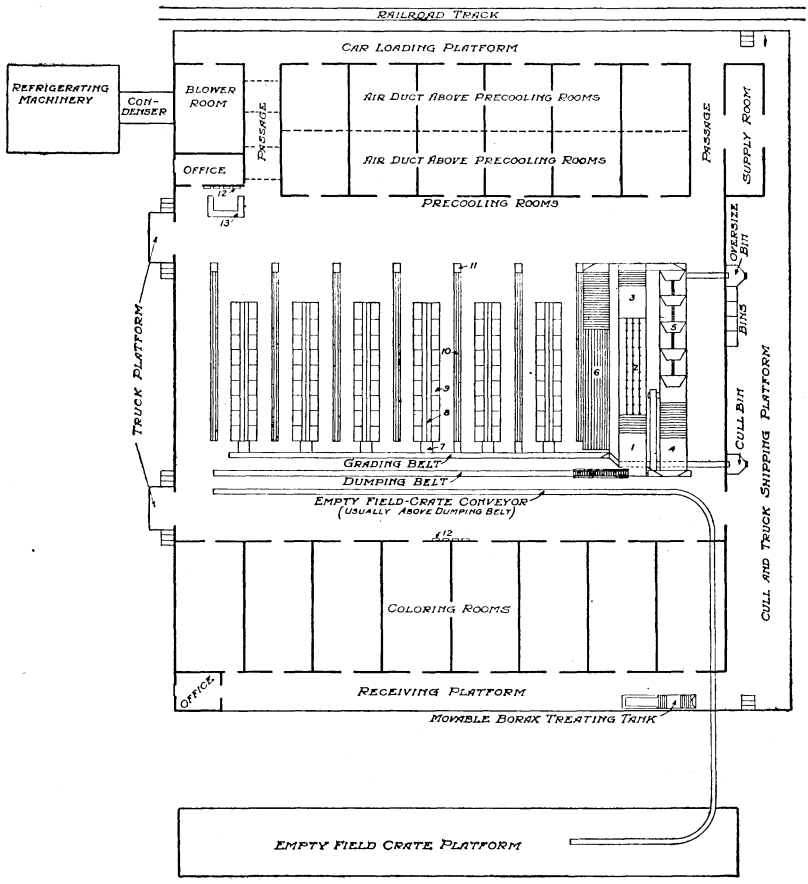

FIGURE 6.—Floor plan of a typical packing house: 1, Soaking tank; 2, scrubbing brushes; 3, second or borax tank; 4, wax-emulsion tank; 5, drier with fans and two trip conveyors (underneath is another conveyor moving in the opposite direction, with fruit from the borax tank); 6, polishing brushes; 7, fruit-marking machinery; 8, sizing rollers and conveyors; 9, packers' bins; 10, packed-box conveyor; 11, lidding machine and control for packed-box conveyor; 12, switchboards; 13, foreman's desk.

mold and green mold organisms occur together, but the olive-green form is the more common.

Infection occurs for the most part through mechanical injuries such as wounds caused by clipper cuts, bruises, etc. It may also occur while the fruit is on the tree, especially after cool, rainy periods when some fruit splitting occurs. Blue mold infection also spreads by contact in packages. Susceptibility increases with advancing maturity.

The first and foremost step in preventing penicillium rot is careful handling at all stages to prevent mechanical injury of the fruit, and

general sanitation in the packing house to reduce the sources of chance infection. Antiseptic dips such as a 5-percent borax solution, as described elsewhere in this bulletin (p. 12), are quite effective in reducing losses from these rots. The antiseptic treatment must be given promptly, i. e., within 6 or 8 hours after harvest. Refrigeration if promptly applied to reduce the temperature of the fruit below the optimum for growth of the decay organisms is also effective in reducing losses, particularly during transit.

Fruit that has been subjected to the high temperature required in the degreening treatment is very much less susceptible to penicillium rot than similar fruit held at ordinary air temperatures, because the penicillium fungi do not long survive exposure to such high temperatures. However, this treatment is particularly favorable to stem-end rot.

STEM-END ROT

Stem-end rot is more restricted in its occurrence than the penicillium rots, but it causes greater financial losses. It is a serious problem in Florida and in the West Indies, where the climate is humid, but thus far it has been much less important in Texas and of no consequence in California.

This rot is characterized by a softening and decay of the rind and pulp tissue in the stem area. There is rarely a sharp demarcation between normal and affected tissue, and often there is little if any discoloration of the affected parts. When discoloration occurs it is of a buff to somewhat darker shade. The decay advances rapidly through the core, often reaching the blossom end before more than one-third of the rind has been invaded.

Stem-end rot is caused by either *Diplodia natalensis* Evans or *Phomopsis citri* Fawcett. Frequently both occur in the same fruit. The rots caused by these organisms are identical in appearance. Diplodia rot occurs more frequently during the warmer months, while phomopsis rot has a somewhat lower optimum temperature range. Fruit subjected to unfavorable conditions in the degreening treatment is especially liable to become affected with stem-end rot, usually the diplodia form, the fruit becoming progressively more susceptible with advancing maturity.

For practical purposes it may be considered that all stem-end rot infection occurs while the fruit is on the tree, remaining in an incipient stage in the stem or stem parts until after the fruit is harvested. Under favorable conditions the rot then develops rapidly and can cause heavy losses within 10 days to 2 weeks after harvest.

Treating the fruit with an 8- or 10-percent borax solution on arrival at the packing house, careful operation of the coloring (degreening) rooms, packing the fruit as soon as possible, and placing it under refrigeration immediately thereafter, all are important steps in reducing possible losses, the one last-mentioned being especially important during warm weather.

COLLETOTRICHUM ROT

Colletotrichum rot of citrus fruits is usually of minor importance, although occasionally in a weakened crop it may become troublesome in storage. While it can attack the fruit at any point, the principal region affected is the stem area, where it produces a rot that may be

confused with the other stem-end rots. However, at ordinary temperatures colletotrichum rot develops more slowly than the other stem-end decays. With colletotrichum rot also there is usually a definite line of demarcation between the normal and the affected parts. Ordinarily the latter are slightly sunken and darkened, and the pulpy part of the rind and core becomes dark olive to black, fading into a pinkish to normal cast toward the periphery of the affected parts.

The disease has not been controlled with antiseptics. Borax is not effective, and stronger chemicals have seemed to increase susceptibility to this rot. Refrigeration is the most effective known means of retarding its development.

BROWN ROT

Brown rot, caused by species of *Pythiacystis*, occasionally produces considerable loss in citrus fruits. While it is sometimes serious in California, it is very rarely serious in the Gulf coast region. Prolonged rainy periods with moderate temperatures favor the outbreak of this disease, the presence of which can be detected by a very characteristic odor.

Control measures that can be taken in packing houses consist of culling out all suspicious fruit, soaking the sound fruit for about 2 or 3 minutes in water held at 120° F., and refrigerating it promptly after it is packed.

BLOSSOM-END ROT

Blossom-end rot, caused by *Alternaria citri* Pierce, occurs very commonly but is rarely serious. Oranges are more susceptible than other species of citrus fruit. The disease is not always easily detected by casual examination. Early in the season, before the fruit has lost its green color, infected fruits have a pinkish discoloration around the blossom end, or that portion assumes an orange color prematurely. Later, when the remainder of the fruit assumes the normal color of maturity, this symptom disappears. With seedy varieties often the only outward symptom is a slight lesion across the stylar scar, so inconspicuous that it can hardly be detected by the graders, although in a large percentage of these cases the pulpy tissue of the rind and core close to the blossom end may be dark gray or black. The affected area enlarges very slowly, and very little of the flesh decays except in extreme cases. Navel oranges seem to be most subject to this disease. No special remedial measures have been developed.

ANTISEPTIC TREATMENTS

The logical time to apply an antiseptic treatment is as soon as possible after the fruit is harvested, preferably within a few hours. If the application is delayed even overnight its efficacy against penicillium rot is considerably reduced, and it is not likely to be so effective against stem-end rot.

The use of an effective antiseptic at this point in the packing operation, whether the fruit needs degreening or not, is of prime importance to the consumer as well as to the shipper. In many packing houses it has become a common practice to treat all fruit in a hot borax solution as soon as it comes from the grove, before placing it in

the coloring rooms if it is in need of degreening. Carefully checked experiments have shown that this borax treatment reduces the damage caused by stem-end rot and penicillium rot, which are the most common decays of citrus fruits. The warm, humid air maintained in the coloring rooms is extremely favorable to the growth and spread of rot-producing fungi, and prior to the adoption of the practice of applying borax before degreening a large percentage of decay was always found after the degreening treatment, especially when the coloring rooms were not carefully operated. This loss can be greatly reduced by proper application of the borax treatment before degreening. Several machines for use on the receiving platform have been devised for giving the borax treatment. The fruit is emptied at one end of the platform and passed through a vat containing an 8-percent borax solution heated to about 110° F. for the purpose of

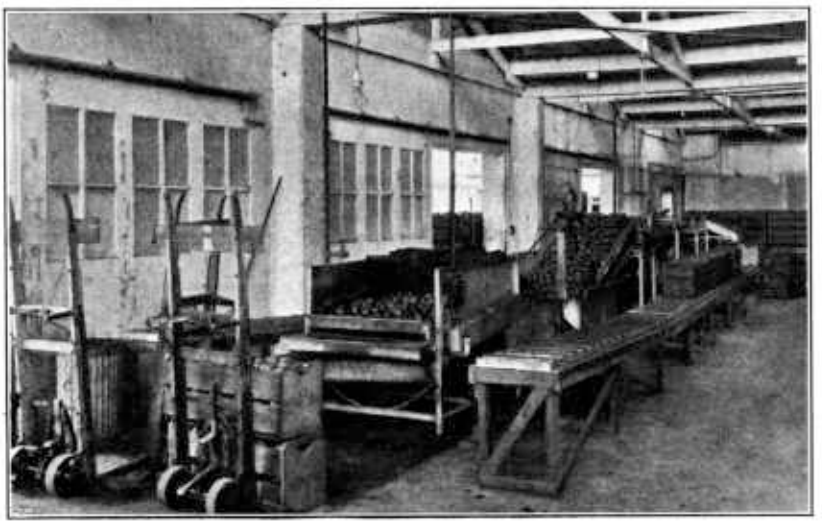

FIGURE 7.—Equipment for giving the fruit a preliminary washing and the borax treatment in one operation. The grading belt at the far end affords an opportunity for sorting out the fruit that needs degreening.

keeping the borax in solution. A conveyor belt carries the fruit out at the other end of the vat, where it is replaced in field boxes and is then ready for the coloring room (fig. 7).

A simple hand-operated device for rapidly dipping both the field box and its contents is shown in figure 8. Its principal advantage is its simplicity and low cost; its principal disadvantage is that the field box as well as the fruit is wetted, thereby adding to the drying problem.

In warm weather a momentary dip in the borax solution is as effective as a bath of several minutes, but in cold weather a longer bath is necessary in order to warm the fruit somewhat and thereby prevent the borax from being thrown out of solution by the low temperature of the fruit.

An important factor in the effectiveness of the treatment, particularly against stem-end rot, is the rate of drying of the borax solution. Ordinarily, better rot control is obtained when it requires several hours to dry the fruit.

COLORING OR DEGREENING

Some of the early oranges, including the Washington Navel, Parson Brown, Satsuma, and other varieties, reach legal maturity before they develop their normal coloring, or at least their full color. Citrus fruit of any variety growing on heavily foliated trees and in dense shade, as does an inside crop of grapefruit, retains much of its greenness even after full maturity. Valencia oranges develop almost full color in winter but do not mature until spring. After new growth starts in the spring these oranges "regreen", particularly at the stem end. Thus, if allowed to remain on the tree until fully ripe the regreened oranges have the appearance of being immature. Likewise late varieties of grapefruit sometimes remain green in the spring, although fully mature.

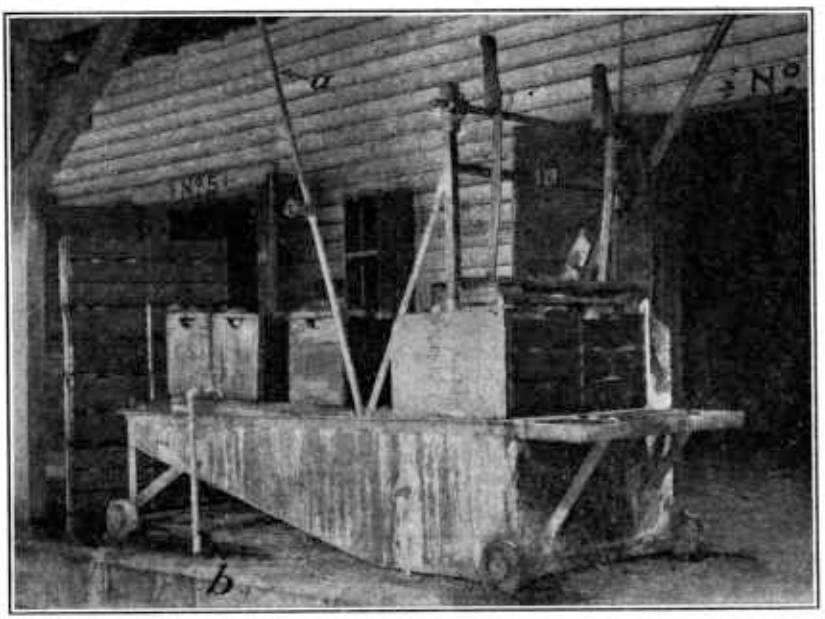

FIGURE 8.—A simple hand-operated device for rapidly dipping field boxes of fruit in borax solution. *a*, Steam line; *b*, water line.

Since citrus fruit generally commands a price commensurate with its appearance, it is highly desirable to make its color and appearance a criterion of its eating quality. With legally mature fruit this may be achieved by the process of degreening, generally known as "coloring." The latter term is somewhat misleading, since no color is added to that which has already been developed naturally. However, in certain other processes sometimes used artificial colors are added, but in such cases each fruit must be labeled accordingly, although where dyes conceal damage or inferiority the color declaration in the label will not bring the product in conformity with the Food and Drugs Act. In reality, degreening or coloring as here described is merely a stimulation of natural processes by which the green pigment (chlorophyll) is made to disappear, and no special labeling is required. By the degreening method a color effect is accomplished in the packing house

within a few days which might otherwise require several weeks on the tree under the most favorable conditions and might not occur on the tree at all. The treatment is really a decoloring or bleaching process. The green pigment masks the yellow and orange-colored pigments. The degreening treatment causes the green color to disappear, thereby unmasking whatever shade of orange may also be present in the rind. The treatment does not produce or change the orange color, nor does it in any sense ripen the fruit. In California the treatment is usually referred to as "sweating", although with lemons it is also known as forced curing.

In balmy weather degreening can be effected in rooms entirely without special equipment, or under tents, although the length of time required under such conditions predisposes the fruit to rapid spoilage.

In the more-modern packing houses degreening is done in one of several types of so-called "coloring" rooms. All are operated on similar principles whereby the fruit is held in warm air of high relative humidity, into which are introduced small quantities of some gaseous reagent, usually either ethylene or the pungent fumes resulting from the incomplete combustion of kerosene variously administered. This conditioned air is circulated through the stacks of fruit by means of fans or blowers. Ethylene, which is almost odorless when diluted, is most commonly used as a degreening agent, as it is much cleaner and does not impart an unpleasant flavor to the fruit as kerosene fumes sometimes do.

When ethylene is used the air-conditioning chambers located above the coloring rooms contain all the equipment necessary to heat and humidify the air and introduce the desired amount of ethylene, as well as fans to blow the conditioned air down into the coloring rooms. The concentration of ethylene used is often as much as 1 part in 5,000 parts of air, and while the minimum effective concentration has not been accurately determined, it is known that 1 part in 50,000 of air continuously maintained is as good as the intermittent application of heavier dosages as commonly practiced under some methods of treatment. In the so-called trickle method of continuous application, now generally used in Florida, 1 to 2 cubic feet of ethylene per carload per day is sufficient. The temperature is raised by means of live steam and radiators; steam jets may also be used to provide humidity in cold weather. A fine spray of cold water is sometimes used in hot weather, both to provide humidity and to lower the air temperature, which for best results should generally be held between 80° and 85° F., with a relative humidity of 90 to 92 percent. The powerful fan in the air-conditioning chamber circulates the air around the stacked fruit and then withdraws it from the coloring room through the slatted floor, after which it is returned to the air-conditioning chamber and is recirculated. Provision is also made for the continuous introduction of necessary fresh air and the removal of the products of respiration.

The fruit in field boxes is stacked 5 or 6 feet high, depending on the weight of the boxes and the height of the ceiling in the coloring rooms. The common practice in Florida is to stack four standard field boxes (fig. 9) or five ⅔-standard boxes. There should be a distance of at least 2 feet, preferably 3 feet, between the top box and the ceiling,

to allow good air circulation and thus insure a more nearly uniform temperature in all parts of the stacked fruit. Experience has shown that it is false economy to construct rooms that allow less than the above-mentioned space between the top box and the ceiling, because they prove to be unsatisfactory and eventually have to be rebuilt.

The time required for degreening is dependent to a great extent on the variety and quality of the fruit, the coloring-room equipment, and the weather. In general it is found that green or nearly green oranges at the beginning of the season require 48 to 60 hours to "color." Oranges picked later in the season may not require more than 36 hours, although regreening Valencias always takes longer. About 12 hours less is required for grapefruit than for oranges. After the fruit has been degreened it should be packed and chilled as soon as possible.

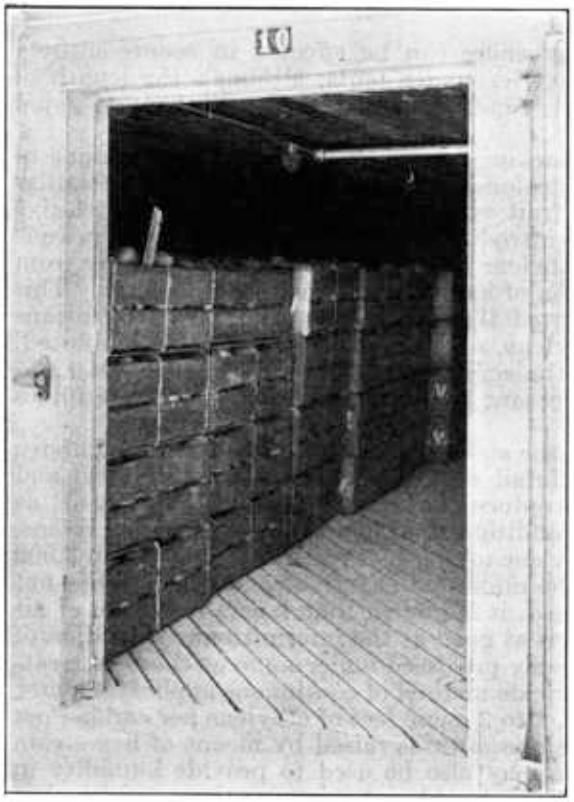

FIGURE 9.—Stacks of fruit in a coloring room. Note the slatted floor. Air is drawn from beneath this false floor to the air-conditioning chamber above and then returned to the coloring room, thereby maintaining uniform conditions throughout the room.

Successful degreening requires alert and intelligent supervision. In the large houses the common practice is for one man who thoroughly understands the process to be placed in complete charge of the coloring rooms. This is a practical necessity, since the degreening treatment is the most delicate and involved part of the entire packing-house procedure.

Some of the more common causes of failure or difficulty in degreening are as follows: If the top fruit colors at a rate different from that at the bottom, heating facilities are inadequate or there is insufficient air circulation to maintain a uniform temperature in different parts of the room. Slow coloring, in cool or cold weather, indicates insufficient heating facilities; in warm weather it indicates insufficient ventilation. Noticeable wilting during the coloring process indicates too low humidity or excessive temperature or excessive air circulation if humidity is moderately high. The greater the rate of air circulation

the higher the humidity must be held in order to prevent excessive wilting. Excessive decay after degreening may be due to insufficient ventilation and air circulation, or to too much humidity if the fruit has not been previously treated with an antiseptic, or it may be due to the use of too much gas.

SEPARATING FROZEN FRUIT

Occasionally freezing temperatures that are sufficiently low to damage unharvested fruit cause a partial or complete loss of juice. Since the frozen fruit may exhibit no outward change of appearance or other symptoms of damage, it cannot be readily detected by the graders; therefore, a specially constructed flotation tank with adjustable screens and flowing water is generally used to separate salable fruit from that which has lost too much juice. This method is not altogether satisfactory, even after considerable changes in weight of the fruit have taken place, but is the best that has thus far been devised. Usually several weeks or even a month or more must elapse after the freeze before this method can be used with any degree of dependability. The borax antiseptic solution can be used instead of water in the separation tank, thereby doing two jobs at once. When separating tanks of this kind are not used, workmen standing beside the soaking tanks are able to detect many dried-out fruits by the manner in which they float, and "high" or "side floaters" are removed with the aid of long-handled kitchen strainers.

FRUIT-HANDLING MACHINERY AND PROCESSES

The fruit is trucked from the coloring rooms, or from the receiving platform if no degreening is necessary, to the "dumping belt." This is the beginning of the mechanical system which carries the fruit through the entire process of preparation for packing. As a matter of fact, the packing-house machinery is made up almost entirely of a series of conveyor belts with accessories, each constituting a packing unit (fig. 10). It requires from 10 to 15 minutes for a fruit to pass through the entire system, depending on the speed and size of the units. In some packing houses the machinery can be run at three speeds, the intermediate one being the normal rate. Sometimes a slower rate is necessary in order effectually to dry or grade the fruit; at other times the condition of the fruit makes greater speed permissible. The belts are generally made of thick corded cotton, but wooden rollers are also used. The grading belt is practically always of the roller type, to rotate the fruit for examination. Fabric belts are used principally for carrying the fruit on a level; rollers are used on inclines. In place of the roller belt there is sometimes used a flexible wire-mesh screen supported by spiral rollers, which impart a wavelike motion to the wire mesh, thus causing the fruit to roll forward. Its use is limited almost entirely to the grading belt.

The dumping belt may be entirely of the roller type, or the fore part may be of ordinary corded belting with a section of roller conveyor just ahead of the soaking tank to eliminate leaves, small twigs, sand, etc., so as to prevent this litter from being carried into the washing tank.

Mechanical dumping devices and box-stacking equipment such as are commonly used in California are not used in Florida. In general, California packing houses have more mechanical contrivances than do the Florida houses, in part, at least, because of the higher wage scale prevailing on the west coast.

The dumper has one of the most arduous tasks in the packing house (fig. 10). He must lift the heavy field boxes to the edge of the dumping belt and pour the fruit out upon the moving belt. He must regulate the speed of his work by the speed of the machinery, because if he dumps the fruit too fast it will clog or pile up somewhere and be damaged by the machinery; on the other hand, if he dumps too slowly he slows down operations and reduces the output. Dumping three or four boxes a minute is the average rate for an ordinary unit. Although a faster rate may be maintained where the equipment is of sufficient capacity, rarely can one man dump more than nine boxes a minute.

FIGURE 10.—Dumping field boxes. This is not only hard work, but it must be done with care to avoid damaging the fruit.

As he dumps the fruit, he either stacks the empty boxes five high on their sides to be trucked away, or, in the larger and more completely equipped houses, places them on an overhead belt above the dumping belt, which conveys them outside the house, where they are stacked to await further use.

As a usual thing, a man is placed at the end of the dumping belt to remove decayed or other obviously unfit fruit. This eliminates unnecessary fouling of the first soak tank, into which the fruit is conveyed and helps to keep the machinery clean.

When packing crops of which only a small percentage needs to be degreened, it is the general practice to sort out this class of fruit as it passes over the dumping belt instead of degreening the entire lot.

WASHING

In order to clean the fruit thoroughly, short transverse scrubbing brushes are placed at the end of the dumping belt so that the fruit has to pass over these scrubbers before it falls into the first soaking tank.

Cleaning solution from this tank is sprayed on the fruit as it passes over the brushes, and drains back to the soaking tank to be used again. These transverse brushes are especially desirable in cleaning oblong-shaped fruit, such as the Valencia orange, in houses where the main scrubbing brushes are of the lateral type.

The soaking tank is filled with water, usually at air temperature, to which is added one of the several detergents or alkaline cleansing materials that are commonly available. In order to improve the cleaning process, however, it is becoming customary to heat the water in the soaking tank to about 100° F. with live steam or steam coils placed in the bottom.

The most commonly employed detergents are cheap soap powders containing chemical fillers. However, a number of other materials are rapidly supplanting soap for this purpose, chiefly trisodium phosphate and other alkali or caustic-base materials such as soda ash, which usually contains rosin soaplike compounds having a characteristic pleasant odor. While these materials are excellent water softeners and satisfactory cleaners, they are not, as is often claimed, effective in reducing stem-end rot, and when applied in the usual manner they are of doubtful merit in reducing the common penicilium rots. These solutions, however, loosen the dirt and other extraneous matter, such as spray residue, which might be on the surface, and so are effective aids in cleaning. As soon as the tank is crowded, the fruit, most of which is floating, is forced against a slatted wooden belt or escalator which runs up at an angle from beneath the surface of the water, carrying the fruit to the top of the next machine, which is the washer.

A drag screen extends across the soaking tank to remove sunken fruit which otherwise would soon be injured by the heat of the solution. The proportion of "sinkers" varies not only as the season advances and the fruit becomes riper, but also from crop to crop according to quality; the higher the quality the greater is the proportion of sinkers, the maximum being reached when the fruit is full ripe. Another method of meeting the sinker problem is the use of a slatted false floor in the soaking tank, sloping toward the escalator. Still another method is the use of centrifugal pumps to circulate the solution in the soaking tank and drive the liquid with considerable force toward the escalator.

Although a washer equipped with a series of transverse brushes has many advantages and is growing in popularity, the most common type has several rows of long circular brushes, made of Tampico or palmetto fiber or other fairly stiff material, placed laterally to the direction in which the fruit is traveling, and sloping downward. The brushes revolve at a high speed, so that as the fruit rolls down over them it is thoroughly cleaned. A spray of soaking-tank solution from pipes paralleling the brushes is played upon the fruit continually, rinsing off the loosened dirt, scale, etc. Near the lower end of the scrubbing brushes, clean water is played on the passing fruit to remove the cleaning compounds. To hold the fruit against the brushes and retard its speed of descent, ruffled canvas flaps are used (fig. 11). These are about 4 inches wide and are attached at one edge to wooden boards parallel with the brushes, the fruit passing between the flap and the brush. The "ruffle boards" are suspended from metal rocker arms and by means of eccentric gearing maintain a backward and forward motion of several inches. Arriving at the bottom, the fruit

falls into the second soaking tank, usually referred to as the antiseptic tank.

In this tank the solution is heated by steam coils to a temperature of 100° to 110° F. As a general practice a 5- to 8-percent borax solution is used as an antiseptic, although occasionally other alkaline materials are substituted. A type of antiseptic which has chlorine as its active ingredient is also used to some extent. However, borax is the most effective material known for preventing the various decays in citrus fruits. The antiseptic tank is of sufficient size to retain the fruit from 3 to 5 minutes, after which a water spray is used to remove the excess borax that may be adhering to the fruit. The fruit is then conveyed into the drier.

Soaking tanks are not used in all packing houses. Where they are not used, fresh water is sprayed on the scrubbing brushes, but the cleaning is less thorough, especially in the case of dirty fruit. Dry

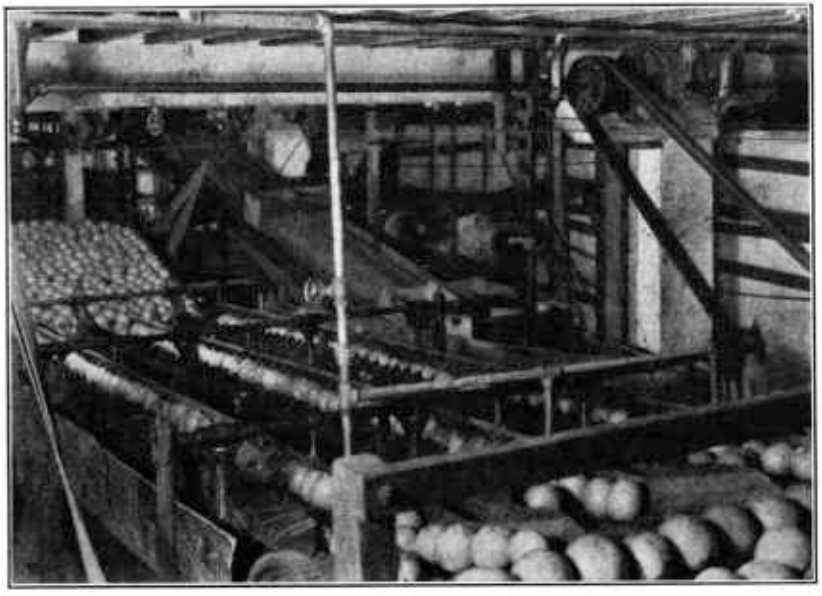

FIGURE 11.—Grapefruit being washed preparatory to packing.

cleaning, or brushing the fruit without wetting, has not generally proved satisfactory. If only dust has to be removed, these methods are effective, but ordinarily other deposits such as remains of scale and other insects, sooty mold fungus, etc., are encountered and can be removed only with difficulty even with the best washing equipment. A dry-cleaning machine usually serves as a combination cleaner and polisher; its use obviates the necessity for a drier, but its disadvantages and limitations far outweigh this advantage.

DRYING

The drier consists of a series of roller conveyors enclosed in a sheet-metal housing, through which a strong current of air is forced by powerful fans. Some of the newer driers are equipped with steam radiators for heating the air that is blown on the fruit to facilitate

drying. Heated air is most useful in increasing evaporation during periods of high humidity and in packing houses in which the soaking tanks are not heated. The conveyor system within the drier is so arranged as to provide two trips from one end to the other and back again, which ordinarily give ample time for complete drying. In Florida, fruit generally can be dried sufficiently without using an enclosed drier, or even without using fans if a long-enough open-roller conveyor is used, but the latter is of the older type of drying equipment and because of its relative inefficiency is not favored. Copper rollers, which pick up moisture by surface tension, and fiber and horsehair brushes, which are arranged transversely and onto which is directed a strong blast of air, are also used as a combination drier and polisher. The chief advantage of this type is its compactness.

The thorough drying of fruit is a matter of considerable importance. It is generally known that damp fruit does not polish well, but the relation of imperfect drying to subsequent decay is not generally recognized by packers. Because the presence of moisture favors the germination of the spores of decay-producing fungi, decay is almost certain to be more serious in fruit that is still damp when packed than in that which is thoroughly dry.

After the fruit is dried it passes to the polisher.

POLISHING

The polishing machine is somewhat similar to the washer already described. It ranges in length from 9 to 36 feet. The two machines differ principally in the material of which the brushes are made. In the polisher the brushes are usually of the horsehair type, resembling the ordinary shoebrush in stiffness, and are used without a water spray. The arrangement of the brushes and ruffled flaps generally is the same as in the washer, although transverse brushes are used in some of the newer polishers. One of the advantages of the transverse brush type is its compactness.

Paraffin is perhaps the most widely used of the various polishing agents and is the only one to be actually applied by the brushes in the polisher. In the application of paraffin, long rolls or bars of the material are usually held against the under side of the revolving polishing brushes. Other polishing materials, such as carnauba wax, pine oil, and rosin compounds, are applied in liquid solution or as emulsions. They require the use of an additional small soaking tank placed immediately before the drier or perhaps added to the solution in the second soaking tank. Melted paraffin and mineral-oil or carnauba wax mixtures applied as a spray while still hot are likewise used to some extent. The polishes usually impart to the fruit a high luster, but this is of uncertain and variable durability. Aside from this, the principal advantages derived from polishes are said to be a reduction in the subsequent wilting of the fruit, a retardation of "aging" effects, and keeping the rind with a fresh, pliable texture. However, with but few exceptions the application of polishing materials does not materially reduce wilting, and when fruit is heavily coated with such materials its flavor may become impaired through interference with normal respiratory activities.

In many packing houses no polishing agent of any kind is used and the natural sheen of clean fruit, brought out by the polishing brushes alone, is preferred.

GRADING

When cleaned and polished, the fruit is ready for segregation into the several grades, and it passes from the polisher to the grading belt. This is another roller belt, usually about 2 feet wide, which continually revolves the fruit and practically eliminates any necessity for the graders to pick up each individual fruit to search for defects.

Commercially, citrus fruit is graded primarily on its surface appearance. Discoloration, scarring, texture of skin, and freedom from disease and parasitic growths are the chief factors taken into consideration in grading. The United States Department of Agriculture grades and standards are usually applied. Starting with the highest, these are as follows: U. S. Fancy, U. S. No. 1 Bright, U. S. No. 1, U. S. No. 1 Russet, U. S. Combination, U. S. No. 2 Bright, U. S. No. 2, and U. S. No. 2 Russet. U. S. No. 3 grade covers all fruit failing to meet the specifications set for any of the preceding grades.[2]

The head grader is responsible for properly grading the fruit, and, usually in conjunction with the house foreman, determines by preliminary examination the particular grades most applicable to a given lot. Ordinarily the fruit of a single run, since it comes from the same grove and has in general the same characteristics, can be sorted into not more than three or four grades. This important work is performed by from 5 to 10 graders standing at intervals along each unit of the grading belt, each segregating fruits of a specific grade as they pass and seeing that, as far as possible, every fruit meets the requirements of the grade to which it is assigned.

The first graders that the fruit reaches are expected to remove the lowest grade and cull fruit. This includes the fruit with the worst blemishes. After being sized, this fruit is usually replaced in field crates and sold in bulk to juice plants or itinerant truckers. Decayed fruit and that which has sustained skin breaks or punctures is sent to the cull bin.

Fruit of the higher grades is generally packed for shipment, but occasionally quantities of first- and second-grade fruit are also sold in bulk, especially that of the very large and very small sizes, which usually sells at a discount.

The fruit meeting the requirements of each of the various grades is transferred to a separate belt and by means of shunts and chutes is finally conveyed through the sizers to the bins receiving that particular grade.

Frequently the individual fruits are marked to indicate the locality where grown, the brand or grade, or any special treatment given. This is accomplished by a motor-driven stenciling machine located between the grading belt and the sizers and so adjusted as to mark each passing fruit regardless of its size.

SIZING

A mechanical fruit-counting device which registers the exact number of fruits of each size is installed in some of the larger houses. Such machines assist in keeping proper records of each grower's fruit. They eliminate the necessity of estimating the quantity of fruit remaining in each of the various bins and the shutting down of the entire machinery, with consequent loss of time, when shifting

[2] The specifications for these grades can be obtained by application to the Bureau of Agricultural Economics, U. S. Department of Agriculture, Washington, D. C.

from one grower's crop to another. They are especially useful in cooperative associations where many small crops must be packed.

There are eight or nine bins with canvas bottoms arranged in rows at right angles to the grading belt. Each row has its own set of automatic sizers, for in order to obtain a uniform pack the fruit in each container must be of the same approximate diameter. The sizers in general use consist of revolving wooden or metal rollers set parallel to and at varying heights above the conveyor belt which moves along the upper edge of the bins and is inclined toward them (fig. 12). When an individual fruit reaches the roller that will allow it to fall

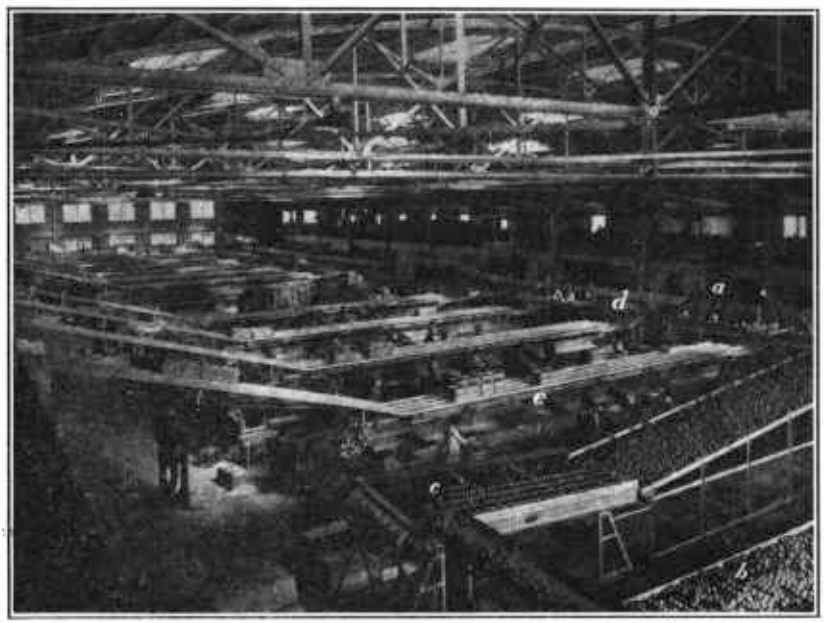

FIGURE 12.—Scene in a well-equipped packing house, taken from the top of the range of precooling rooms: *a*, Range of coloring rooms with air-conditioning units overhead; *b*, fruit on conveyor belt, having passed through the washer and drier; *c*, fruit on polishing brushes; *d*, graders sorting out culls and second-grade fruit; *e*, mechanical sizing units.

through into the bin below it does so; thus fruit of the same approximate diameter is segregated into separate bins. Citrus sizes are designated by the number that can be packed in the standard box. The sizes used and the corresponding diameters are shown in table 1.

TABLE 1.—*Maximum and minimum diameters for the different sizes of oranges and grapefruit as packed in Florida boxes*

Size	Diameter of oranges		Size	Diameter of grapefruit	
	Minimum	Maximum		Minimum	Maximum
	Inches	*Inches*		*Inches*	*Inches*
96's	3 9/16	3 11/16	36's	5	5 3/16
126's	3 3/16	3 5/16	46's	4 11/16	5 1/16
150's	3	3 1/16	54's	4 9/16	4 13/16
176's	2 14/16	3 2/16	64's	4 3/16	4 9/16
200's	2 12/16	3	70's	3 15/16	4 5/16
216's	2 10/16	2 14/16	80's	3 12/16	4 2/16
250's	2 8/16	2 12/16	96's	3 9/16	3 15/16
288's	2 6/16	2 10/16	126's	3 3/16	3 11/16
324's	2 4/16	2 8/16			

In most cases, bulk citrus fruit is sold on the basis of the same minimum and maximum size specification as is boxed fruit (table 1).

Despite all the handling to which citrus fruit is subjected in the packing house, the machinery and procedures are so operated that ordinarily there is little injury to oranges and grapefruit before they reach the packers. This is especially true when the equipment is kept constantly in good repair. Tangerines, however, are easily injured on roller conveyors and on the polishing brushes. For this reason packers of tangerines prefer to use a liquid polishing material that dries with a luster and does not require brushes.

PACKING

Unlike all other packing-house employees, who are paid on an hourly scale, the packers work on a piece basis, receiving so much per packed container. The prevailing scale, based on the standard box, is about one-half as much for grapefruit as for oranges. Tangerines

FIGURE 13.—Oranges being packed in standard boxes. Note the bulge toward the center partition of the box in the foreground. Note also the cardboard collars at the top of the box to protect the upper layer of fruit from "box cuts."

are packed in half boxes, and the rate is about the same as for full boxes of oranges. The pack inspector is responsible for proper sizing and packing, and also assigns the packers to various sizes in rotation so as to equalize the work and to give each packer a chance at the larger sizes, which of course can be packed more quickly (fig. 13).

Various containers are used, but by far the most common in Florida and Texas is the standard Florida box, which has a capacity of 1.60 bushels. It is constructed of pine or gumwood and is somewhat larger than the standard California box, which has a capacity of 1.47 bushels. The inside dimensions of the Florida box are: Length, 24 inches; width, 12 inches; depth, 12 inches. The California box is 24 by 11½ by 11½ inches inside. In Texas both the Florida and California boxes are used, although the former is in more general use because of its adaptability to grapefruit, which constitutes the bulk of the Texas crop. The half boxes (four-fifths of a bushel) are commonly known as "half straps" on account of a method sometimes used

in shipping them, in which two boxes are strapped together bottom to bottom. These half boxes have the same dimensions as the standard boxes except for the depth, which is 6 inches. This container is widely used for tangerines and Satsuma oranges. A ⅘-bushel box, 9½ by 9½ by 19⅛ inches, patterned after the standard box, is used for small oranges and tangerines. Bushel boxes, also patterned after the standard box, and bushel baskets, which are packed with "ring face" only, are also used, the first almost exclusively for tangerines. Perhaps the most economical sturdy package in use is the collapsible crate, of which there are several designs. The cylindrical crate with slatted sides and the wired crate (fig. 14) are typical examples. The cheaper

FIGURE 14.—Collapsible crates adapted to the lower grades of fruit. Since these fruits are not wrapped, the packing cost is reduced.

crates are especially adapted for the lower grades of fruit and for certain markets. They are not adapted to the bulge pack, but there is an increasing use of them in sales made on a basis of delivered weight rather than on count, as is the case with other containers except the smaller bags, which are sold on the basis of both weight and count. The open-mesh bag is coming into wide use as a container for both oranges and grapefruit, especially for distribution through chain stores. The most popular sizes of bags for oranges are those holding one-half of a standard box (four-fifths of a bushel, or about 40 pounds), 8 pounds, and 5 pounds. The first two sizes are also used for grapefruit (fig. 15).

Box shook, consisting of ends, center partitions, sides, and bottoms, is usually bought by the packing house and assembled there, generally by automatic nailing machines, although in the smaller houses this work is sometimes done by hand. A particular section of the house is devoted to this work. In Florida it is often a balcony over the coloring rooms or precooling rooms; in Texas and California it is

usually the basement. After the boxes are nailed together they are labeled and stacked to await use. As needed, they are placed on runways above or below the packing bins so as to be easily available to the packers.

The packer's duty is to wrap each individual fruit and place it symmetrically in the container in such a manner as to provide a firm pack that will withstand the jolts and jars incurred in handling and shipping without sustaining bruises or other damage. The maximum and minimum diameters for different sizes of oranges and grapefruit as packed in Florida boxes are shown in table 1 (p. 23). The diameter referred to is the greatest dimension of the fruit at right angles to a line through its axis from stem to blossom end. Similar data for tangerines would not be altogether dependable because of their variable shape and their tendency to become spongy as maturity advances. Figure 16 shows how the various sizes are packed in the different

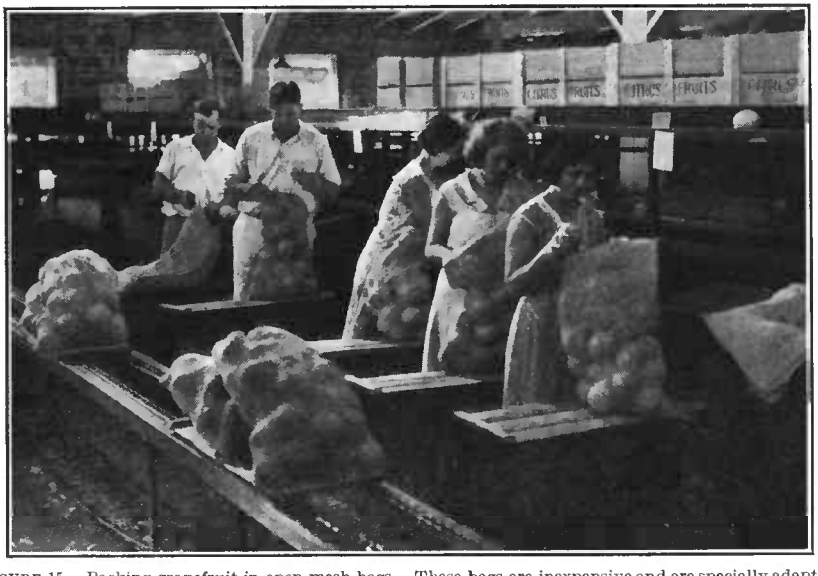

FIGURE 15.—Packing grapefruit in open-mesh bags. These bags are inexpensive and are specially adapted to the lower grades of fruit and for certain trade channels.

layers of standard boxes. For wrapping the fruit a slightly oiled tissue paper is ordinarily used. Oiled paper is used because it is easier to work and somewhat tougher than the common tissue paper. To secure a firm pack the fruit is somewhat pyramided toward the center of the box. This is done by pressing down the fruit in the ends of the boxes and also by placing a little larger fruit against the center partition. There is always a slight variation in sizing, which makes possible such selection from the same bin.

On an average, about 40 reams of paper are required for each 100 boxes of oranges or tangerines and about 20 reams for a like number of boxes of grapefruit. The sizes of wrapping tissue used for fruit of various sizes are shown in table 2.

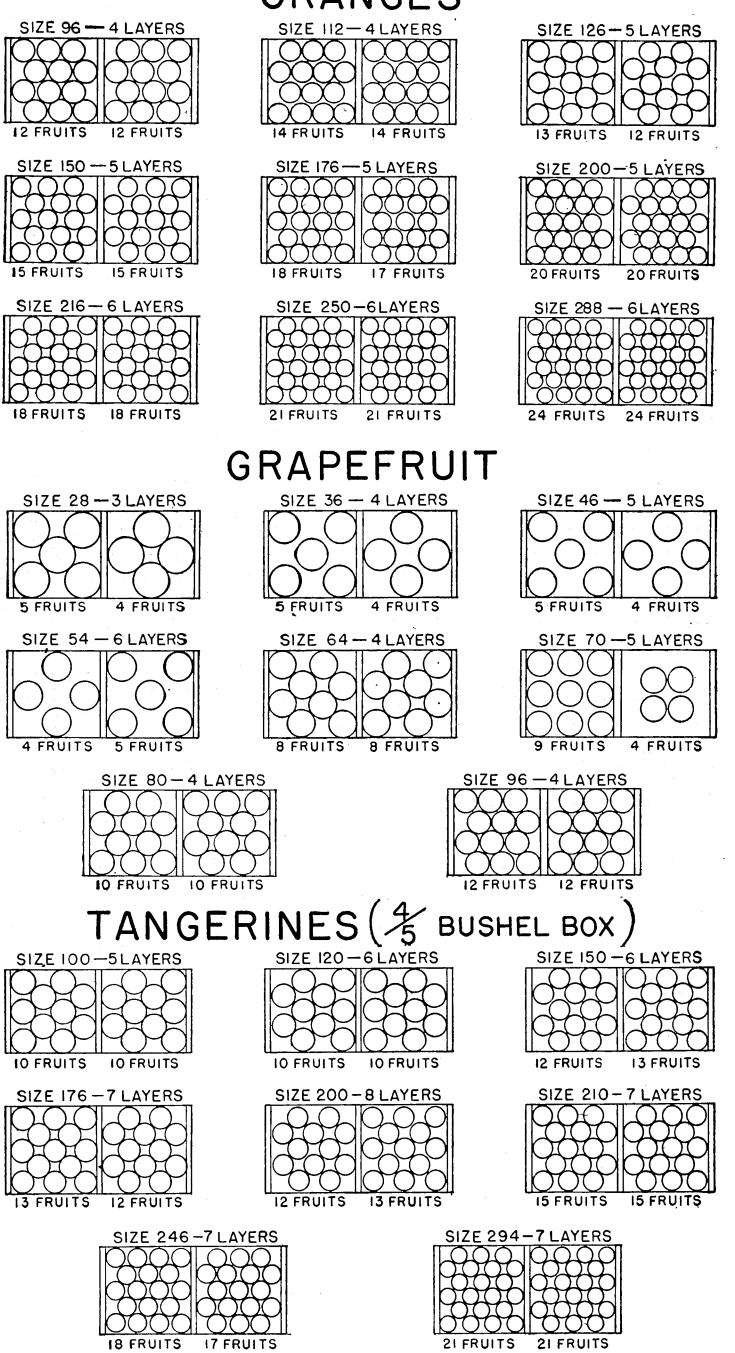

FIGURE 16.—Chart showing the various packs used for oranges, grapefruit, and tangerines. The left half of each diagram shows the arrangement of the fruits in the first or bottom layer of the box and each alternate layer above it, while the right half shows the arrangement of fruits in the second layer from the bottom and each alternate layer above that.

TABLE 2.—*Sizes of tissue wraps used on citrus fruits in the Gulf Coast States*

Size of tissue wrap	Size of citrus fruits		
	Tangerine	Orange	Grapefruit
9 by 9 inches	250's and smaller		
10 by 10 inches	196's and 216's	250's and smaller	
11 by 11 inches	168's, 144's	200's, 216's	
12 by 12 inches	120's and larger	176's and larger	
13 by 13 inches			126's.
14 by 14 inches			96's.
15 by 15 inches			64's, 70's, 80's.
16 by 16 inches			46's, 54's.
17 by 17 inches			36's.

Fruit is sometimes packed unwrapped in standard boxes. In the case of oranges of size 250 and smaller, the so-called "blind pack" may also be used. With this, only those fruits in the top and bottom layers and those that are visible through the open spaces in the box are wrapped.

Most of the packing is done by women who have mastered the art after long practice. With an adequate supply of fruit an efficient packer can turn out about 70 to 80 boxes of oranges and about the same number of the smaller packages of tangerines per day, while an average of about 150 boxes of grapefruit can be packed.

Shippers generally place major importance on the appearance of the package, and in the larger houses a supervisor watches all packers closely in order that a high standard may be maintained. The printing on exposed wraps is arranged in an orderly manner and no "flags" (loose paper) are permitted to show through the open spaces in the box. In many packing houses the wrap is twisted tightly around each fruit, which slows down the rate of packing. In every house the wrap is twisted on each fruit placed along the open spaces in the box and in the top layer. In some packing houses only the fruit in the top layer of the box is wrapped with the tightly twisted paper and the remainder is merely cushioned in a wrap. This practice is known as "wadding", but it is not generally favored because it is thought to encourage carelessness elsewhere.

The packed boxes are placed on a conveyor belt which carries them to the nailer, who nails on the tops. To make the package more secure he fastens a metal strap across the top over the center of the box, the ends of the straps being nailed through the sides at the center partition. This work is done with the aid of a lidding press (fig. 17). Elaborate hydraulic or mechanical lidding presses are sometimes used. The press holds the top down on the box so that it can be nailed in place. A mechanically operated combination top press and nailer is similarly used to some extent. As the boxes are lidded, the nailer stacks them on the floor, four high, on their sides. From this point on care must be taken to prevent any undue pressure on the bulged top. The amount of the bulge varies with oranges from 1¼ to 2¼ inches and with grapefruit from 2 to 3 inches, measured above the sides. If the bulge is below the minimum range mentioned a "slack pack" is likely to result by the time the fruit reaches the market, and the chances of damage in transit are greatly increased. Likewise, too high a bulge, as often demanded by buyers, especially

in an excessively tight pack, undoubtedly causes additional damage through its heavy pressure. The danger of box cuts is also increased by high-bulge packs, but this damage can be averted to some extent by the use of cardboard collars around the tops of the boxes (fig. 13).

PRECOOLING

Precooling is the rapid chilling of the fruit before shipment and is accomplished either in the car after loading or in specially constructed rooms.

Unless the fruit is loaded and shipped within 24 hours after picking, especially during warm weather, it is usually stacked in heavily insulated precooling rooms which are refrigerated by forced draft of air from a bunker room. In figure 9 is shown a lay-out and plan of a precooling room with overhead air ducts connected to the blower room over the intervening passageway.

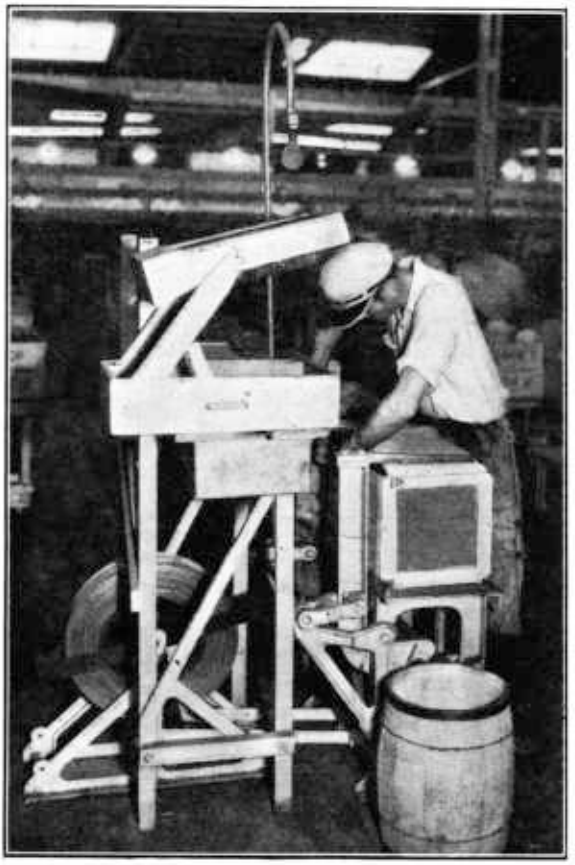

FIGURE 17.—A common type of lidding press.

Figure 18 shows how the air is circulated during precooling in a typical precooling room. The cold air, under pressure from the blower room, is forced through one of the two air ducts and down into the precooling room below through an opening in the ceiling. It then goes through the stacked fruit and up through the opening in the ceiling at the opposite side of the room into the air duct above for eventual return to the blower room, thus completing the cycle.

A canvas curtain extending across the center of the room is lowered from the ceiling to the top of the stack by means of a rope, to prevent short circuiting of air currents over the load, and forces them through the stacked fruit (fig. 19). Intermittently, the direction of the air is reversed, to equalize the temperature of the room.

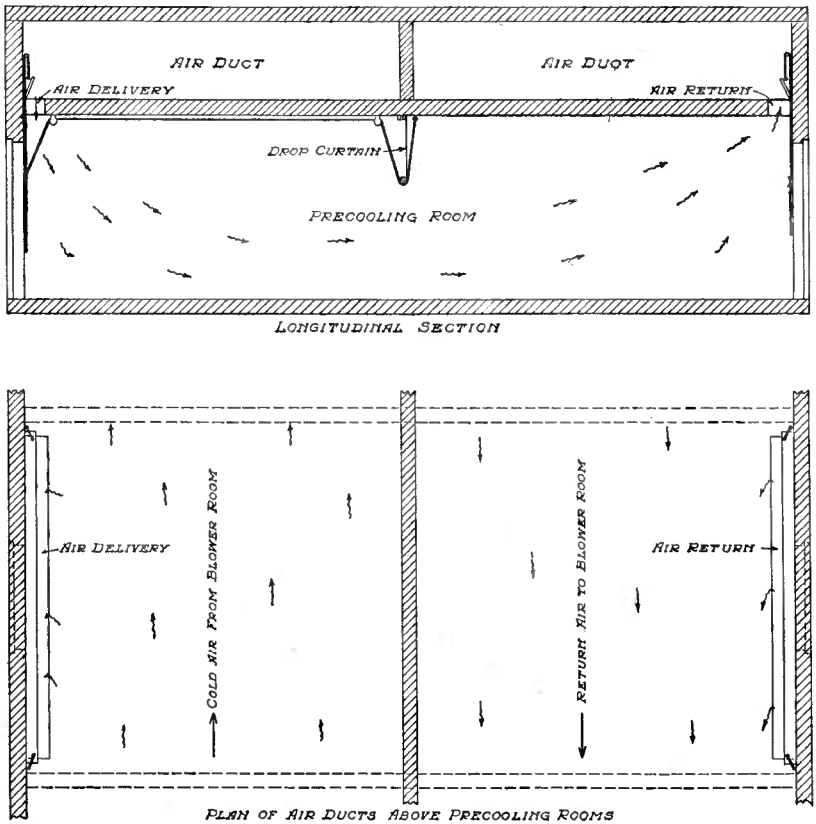

FIGURE 18.—Diagram showing air circulation in a typical precooling room.

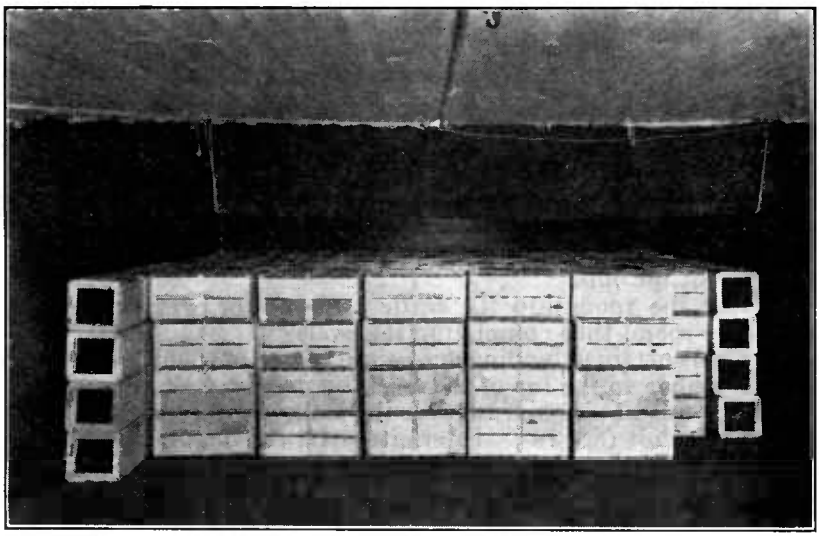

FIGURE 19.—Precooling room, showing method of stacking fruit and the canvas-curtain baffle which directs the air current. The current is reversed periodically.

The blower room is heavily refrigerated by means of brine spray, brine coils, or coils for direct expansion of ammonia. Although the details of application vary considerably in different plants, the same general principle is followed in all precooling operations.

For precooling, the boxes of fruit are most conveniently stacked four high (fig. 19), on their sides, so that they can be moved about with trucks instead of having to be handled individually. To get best results the precooling room should be rather completely filled, and an air blast of 4,000 to 5,000 cubic feet per minute should be used in rooms of one carload capacity. The air entering the precooling room is generally held at 32° F. or slightly lower, and its direction is reversed every 30 minutes or every hour. The frequent reversal in the direction of the air blast reduces the chance of freezing the fruit located where the cold air enters the room, and facilitates a more nearly uniform cooling of the entire lot. Ordinarily, the average rate at which the temperature of the fruit is reduced is about 2° or 3° per hour, and with adequate equipment it can be cooled even more rapidly. Precooling rooms must be watched carefully during operation, and the temperature of the fruit should be observed frequently to prevent damage, especially if the temperature of the air blast is lower than the freezing point of the fruit. The freezing point of oranges and grapefruit is slightly under 29° F.

Ordinarily, precooling the fruit to a temperature of 36° F. or below can be accomplished satisfactorily in less than 24 hours. This enables the same room to be refilled every day if desired, a matter of special importance when fruit is moving briskly. Although rooms of this type are not entirely satisfactory as cold-storage chambers for holding fruit a long time, they are sometimes used for this purpose. In this connection they are particularly useful in assembling special orders for mixed cars or for the less-abundant sizes. Fruit can, of course, be precooled in ordinary cold-storage rooms, a practice largely followed in California, but ordinarily it is not possible to secure such quick and uniform cooling by this method.

In taking fruit temperatures the ordinary type of mercury or spirit thermometer with a pointed bulb that makes it easy to insert the thermometer in a fruit is most commonly used. Ordinarily these thermometers are placed in a fruit in a box just inside the door of the room, where readings can be made most conveniently. However, such readings do not accurately indicate conditions in the center of the stack and are usually lower than the temperature of the bulk of the fruit because of the free exposure of this location to the air blast. Allowance must be made for this in connection with such records. Electric resistance thermometers can be placed in different parts of the room and read in the office or at any other distant point without the necessity of going into the rooms. While this equipment has many advantages, it is expensive and is not generally used. Recording electric resistance thermometers also are used, to a very limited extent.

The most important benefit from precooling is in checking the growth of decay organisms. Such rapidly growing decays as the stem end rots, which thrive best at high temperatures, are effectively retarded when the fruit is promptly precooled. The spores of many other decay organisms will not germinate at low temperatures, so

that these rots are likewise retarded or prevented altogether as long as the fruit is held at a sufficiently low temperature.

Although precooling facilities for citrus fruit as largely developed in Florida entail heavy expense for installation and operation, they have proved to be good investments, since it has been found that precooled fruit shipped with or without transit refrigeration, depending upon outside weather conditions, arrives at the market fresher in appearance than that shipped under ventilation, and ordinarily commands a better price. In seasons of very low prices, however, it may not be profitable to precool the cheaper grades of fruit. There is greater need for precooling when the shipping season extends through the warmer months than when shipments are made only during the coolest part of the season.

RAIL TRANSPORTATION

When ready for shipment by rail, the boxed fruit is trucked into the cars and loaded. For short hauls or in mild weather ordinary ventilated box cars may be used, but usually refrigerator cars are employed. The boxes are stowed according to the size of the car and the number of boxes to be placed in it. Until recently the ordinary load of citrus fruit consisted of 360 boxes stowed in two layers on end, generally six rows wide and loaded the full length of the car. Now, however, on account of the freight charges, the minimum load is increased to 444 boxes and a third layer of boxes is placed lengthwise on their sides on top of the first two layers. This load is braced to prevent shifting. All rows are strengthened by the use of wooden strips nailed across the boxes to secure the entire load. Another method of loading frequently used is to place all of the boxes on their side. When the car dimensions do not exactly fit the load, the slack is taken up by constructing a temporary bulkhead out of 2- by 4-inch lumber placed at the bunker. In the case of the smaller loads the bulkhead may be placed in the doorway instead of at the bunker.

When cars are loaded in bulk or with open-mesh bags, the floors and often the sides of the car are padded with excelsior (fig. 20) to lessen the possibility of bruising the lower fruit by the weight of that on top. A few double-deck refrigerator cars have also been constructed especially for carrying this kind of load. The bulk shipments usually comprise the lower grades of fruit or consignments to nearby centers. The carrying quality of bulk shipments depends entirely upon the condition of the fruit when loaded, the kind of handling it receives, and the length of time it is in transit.

Although some fruit is shipped in ventilated box cars, most of the rail shipments are made in refrigerator cars having ice bunkers in each end, with hatches for loading the ice. These hatches are fitted with hinged lids that can be raised to ventilate the load if refrigeration is not desired. When precooled fruit is shipped, ice may or may not be placed in the bunkers, depending largely on weather conditions. In hot weather the bunkers are usually iced before the car is loaded but are not reiced in transit except on shipments a long time in transit. In cool weather bunker ice is usually omitted and the cost of transit refrigeration saved.

Fruit loaded at ordinary temperature may be given standard refrigeration, initial icing, or merely ventilation. Standard refrigeration

consists in filling the bunkers with ice before loading the car, followed by reicing to capacity at all regular icing stations en route. The cost of standard refrigeration varies with the length of haul and the number of reicings.

Initial icing consists in filling the bunkers only once, usually before the car is loaded or at the first icing station thereafter. Initial icing, if done by the shipper, carries a bunker rental charge in addition to the cost of the ice supplied.

With standard ventilation no ice is used, but the hatch covers over the bunkers are closed by the carrier when the outside air temperature falls to 32° F. and are opened again when the air temperature rises above 32° F. The shipper sometimes gives special instructions regarding the manipulation of the vents.

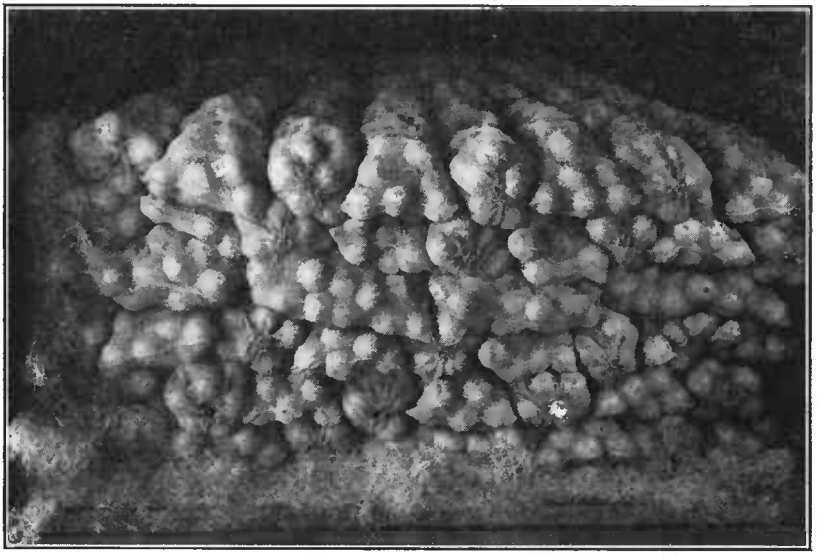

FIGURE 20.—A load of small-size grapefruit in bags. Note the excelsior cushion on the floor and the layer of bags placed crosswise. Excelsior is used as a cushion to prevent bruising, and the cross loading makes the bags carry better.

Since the greater part of the citrus crop of the Gulf States is shipped during the cooler months, it is possible to take advantage of the outside temperature in cooling the shipments as they move to northern markets and thereby to effect a considerable saving in transit-refrigeration costs. Since the organisms that cause decay in citrus fruit develop very slowly at temperatures below 50° F., this may be regarded as a safe maximum fruit temperature to maintain in transit, while 34° F. is a satisfactory minimum. When weather conditions in transit are such that the temperature of the fruit can be maintained within this range by proper ventilation, that service is more economical and just as satisfactory as refrigeration.

WATER TRANSPORTATION

Although ships have hauled Florida citrus fruits to market since the beginning of the industry, it is only within the last few years that this form of transportation has become of major importance. Good

roads and fast trucks, which facilitate delivery of the fruit to the various ports of call, together with the cheaper carrying charges offered by steamship lines and the lower market prices that have recently prevailed, have been largely responsible for this increase in the use of water transportation. The fact that steamship lines are equipping more and more ships for the efficient transportation of citrus fruits indicates an increasing demand for this type of service. One of its principal advantages is the ability of most ships to maintain the temperature of precooled fruit satisfactorily through the provision of adequate mechanical refrigeration capacity and technical supervision of its operation en route.

The fruit is shipped by rail or motortrucks to the most convenient port where shipside precooling plants are operated either by the steamship lines or other interests. The ships are equipped with specially constructed fruit chambers in which either ventilation or refrigeration service is available.

In order more effectively to ventilate nonrefrigerated chambers, blowers are installed in some ships. They are arranged so as to force or draw air from the lower part of the fruit chambers and expel the accumulated waste products given off by the fruit.

Since refrigerated chambers usually have only enough refrigeration capacity to hold the temperature of precooled fruit and not enough to lower the temperature of warm fruit very rapidly, the fruit usually must be precooled before being loaded. This may be done at the packing house and the fruit transferred to shipside in refrigerator cars or in insulated vans, but this practice has not proved entirely satisfactory, and shipside precooling has been found preferable.

MOTORTRUCK TRANSPORTATION

The motortruck has become one of the most important means of transporting citrus fruits from the producing areas and distributing centers to the consuming districts. This is made possible by all-weather highways and the great number of motortrucks available. By many packing houses the truck is preferred as a means of transportation not only because it is more rapid but also because it is cheaper than rail or water shipment. The motortruck affords a speed of distribution not previously possible, and by its use a shipper may quickly and directly reach districts away from railway lines and seaports. There are two general types of service rendered by trucks: (1) Transportation of fruit over more or less fixed routes, such as hauling fruit in standard containers from the packing house to the shipping point or from distributing centers to merchants in contiguous territory; and (2) transportation of fruit, frequently from points of production, by itinerant peddlers, who usually buy the fruit in bulk for cash. They haul it to distant points, where they may dispose of it at retail along the roadside or sell it to small merchants.

COLD STORAGE

Although it is generally considered that oranges and especially grapefruit can be "stored" better by leaving the fruit unpicked on the tree than by placing it in cold storage, conditions sometimes arise that make it necessary to store citrus fruit for various lengths of time.

Glutted markets, embargoes, and rapid changes in the fruit itself (e. g., "going back", or regreening, while still on the tree) are the principal reasons for placing citrus fruit in storage.

In the case of both oranges and grapefruit, advanced maturity at the time of picking is not favorable to an extended storage period. In general, the less mature the fruit is when harvested the better it holds in storage.

Oranges ordinarily hold up well in cold storage at 32° to 38° F. for 1 or 2 months, but grapefruit cannot be stored as satisfactorily at low temperature for more than a short time, because at storage temperatures of 32° to 40° F. it frequently develops scald or storage pitting after being held for 4 or 5 weeks. These troubles may appear while the grapefruit is held at the low temperature or may develop rapidly after the fruit is withdrawn to a warm temperature. Susceptibility to these troubles varies greatly. Fruit from one grove may pit or scald within 30 days, whereas that from another grove may remain entirely free or show no symptoms of these physiological diseases until weeks later. While these troubles are only skin blemishes, they are unsightly and affect the market value of the fruit.

Neither pitting nor scald develops to a serious extent on grapefruit held at about 50° F., but this storage temperature is more favorable to the development of fungus rots than are lower temperatures. Consequently, a 50° F. temperature for long storage is not as satisfactory for fruit subject to stem end rot as for that not susceptible to this disease. However, with the proper use of antiseptic washes at the time of harvesting, danger from loss on this account can be greatly reduced and advantage taken of this favorable temperature for storing grapefruit.

SPECIAL HANDLING OF LIMES

The lime-producing industry is still comparatively young, small, and unorganized. Packing and handling methods are not standardized as with the other commercial citrus fruits, and the volume of shipments is not sufficient for carlots, so consignments usually are forwarded in small lots by express or boat. The standard citrus crate of 1⅗ bushels capacity is sometimes used, although crates one-half, one-fourth, and one-eighth of this size are also in common use.

Limes must be harvested and handled quite differently from oranges, tangerines, and grapefruit. The lime tree usually carries at the same time fruit of all ages from blossom to full maturity. Selection of fruit at any particular intermediate stage of maturity, therefore, is difficult, and since no definite maturity standards have been adopted, as with oranges and grapefruit, the limes are picked mainly according to color. In harvesting, the lime is pulled from the tree rather than clipped as are most other citrus fruits, and on account of the hot, humid climate where limes are grown they must be handled expeditiously and with such precautions as may be taken in order to reduce losses from rot and scald.

The Tahiti or Persian lime is known to the trade as the green lime. It must be picked while still very green in color; but if it is picked too green there is a deficiency of juice, and a dark rind scald may develop. However, if the fruit is left on the tree until it is almost

ready to break color a peculiar blossom end scald may also develop either before or soon after picking. Lack of knowledge concerning this fact has been a serious handicap to the development of the industry, since until recently the fruit was allowed to become too mature before being harvested. In recent years, however, when less-mature fruit has been harvested less trouble has been experienced from this scald. The optimum stage of maturity for harvesting is determined by the general appearance of the fruit, mainly by the rind texture. As the fruit develops juice it gradually loses its roughness, and when it becomes comparatively smooth and slightly soft it is ready to be picked. The fruit begins to ripen in May, but the bulk of the crop is harvested between July and November, mostly in September and October. This fruit is not given the ethylene treatment, as the trade accepts the green-colored fruit in preference to that which has become partially or completely yellowed.

There are few packing houses equipped with machinery for handling limes. Where such machinery is found it is limited to polishing brushes, a grading belt, and sizers.

The Mexican or Key lime, sometimes referred to as the sour lime, has perhaps the most difficult handling problem of any of the commercial citrus fruits. The plantings are small and scattered, usually located in rather inaccessible places, and the trees are very thorny, which makes picking a vexatious task.

The fruit is picked after it has lost some of its deep-green color, the juice sacs have lost their "riciness", the rind has become quite smooth, and the fruit feels slightly soft. If the fruit is picked before this stage there is a tendency for a dark rind scald to develop, rendering the fruit unattractive in appearance, so that it does not command as good a price.

When picking is done at the right stage of maturity the green pigments in the rind gradually fade until it becomes uniformly yellow. As with the Tahiti lime, the bulk of the crop is harvested between July and November, mostly in September and October. Ordinarily this fruit is not given any special coloring or antiseptic treatment, nor is it packed by count. It is usually graded only according to size and condition.

A characteristic tan rind scald frequently develops on the rind of limes, either while in transit or on the market. The cause and control of this blemish are unknown.

HANDLING FRUIT IN TERMINAL MARKETS

Citrus fruit shipped to terminal markets may be forwarded on order or for sale by agents or brokers or at auction. In the larger cities much of the fruit is handled through the regular fruit auctions. In these auctions representative samples of the various lots are displayed to prospective buyers, and the entire shipment may or may not be unloaded prior to the auction. When the fruit is thus displayed, the presence of decay, defects, and blemishes, as well as the general condition of the fruit and pack, are clearly discernible and are considered in the bidding on the various lots. The value of all the precautions taken in handling and packing the fruit becomes

evident at this time and is usually reflected in the sales price returned to the shipper.

Careful handling and giving attention to the temperature requirements of the fruit continue to be important in its satisfactory disposal through the retail trade and in the home. It should not be kept at warm temperatures any longer than necessary, since its flavor deteriorates under these conditions and fungus rots will develop rapidly. In the consumer's home the fruit should be held in the household refrigerator until used.

DEPARTMENT OF AGRICULTURE WHEN THIS PUBLICATION WAS LAST PRINTED

Secretary	HENRY A. WALLACE.
Under Secretary	M. L. WILSON.
Assistant Secretary	HARRY L. BROWN.
Director of Extension Work	C. W. WARBURTON.
Director of Finance	W. A. JUMP.
Director of Information	M. S. EISENHOWER.
Director of Personnel	W. W. STOCKBERGER.
Director of Research	JAMES T. JARDINE.
Solicitor	MASTIN G. WHITE.
Agricultural Adjustment Administration	H. R. TOLLEY, *Administrator.*
Bureau of Agricultural Economics	A. G. BLACK, *Chief.*
Bureau of Agricultural Engineering	S. H. MCCRORY, *Chief.*
Bureau of Animal Industry	JOHN R. MOHLER, *Chief.*
Bureau of Biological Survey	IRA N. GABRIELSON, *Chief.*
Bureau of Chemistry and Soils	HENRY G. KNIGHT, *Chief.*
Commodity Exchange Administration	J. W. T. DUVEL, *Chief.*
Bureau of Dairy Industry	O. E. REED, *Chief.*
Bureau of Entomology and Plant Quarantine	LEE A. STRONG, *Chief.*
Office of Experiment Stations	JAMES T. JARDINE, *Chief.*
Food and Drug Administration	WALTER G. CAMPBELL, *Chief.*
Forest Service	FERDINAND A. SILCOX, *Chief.*
Bureau of Home Economics	LOUISE STANLEY, *Chief.*
Library	CLARIBEL R. BARNETT, *Librarian.*
Bureau of Plant Industry	FREDERICK D. RICHEY, *Chief.*
Bureau of Public Roads	THOMAS H. MACDONALD, *Chief.*
Resettlement Administration	WILL W. ALEXANDER, *Administrator*
Soil Conservation Service	H. H. BENNETT, *Chief.*
Weather Bureau	WILLIS R. GREGG, *Chief.*

U. S. GOVERNMENT PRINTING OFFICE: 1937

For sale by the Superintendent of Documents, Washington, D. C. - - - - Price 5 cents